

THE INVENTION CLAIMED IS:

1. A micro-relay device, comprising:

a fluid non-conductor;

a first substrate and a second substrate bonded together;

5 a channel defined in at least one of the substrates;

liquid metal in the channel;

electrodes spaced along the channel and selectively interconnectable by the liquid metal;

10 an open via defined in one of the substrates and containing the fluid non-conductor; and

a heater substrate comprising a suspended heater element in fluid communication with the open via, the suspended heater element operable to cause the fluid non-conductor to separate the liquid metal.

2. The micro-relay device of claim 1, wherein:

15 the first substrate comprises at least one substrate layer and at least one of a connecting via, the open via, a conductor, an electrode, a subchannel, and a ground plane.

3. The micro-relay device of claim 1, additionally comprising:

20 a subchannel defined in at least one of the substrates, the subchannel extending between the channel and the open via.

4. The micro-relay device of claim 1, wherein:

the first substrate comprises a remote surface remote from the second substrate; and the heater substrate is bonded to the remote surface of the first substrate.

5. The micro-relay device of claim 1, wherein:

25 the second substrate comprises an adjacent surface adjacent the first substrate; and the heater substrate is bonded to the adjacent surface of the second substrate.

6. The micro-relay device of claim 1, wherein:

the second substrate is a multilayer substrate comprising an adjacent layer adjacent the first substrate; and

30 the heater substrate is bonded to the adjacent layer of the second substrate.

7. The micro-relay device of claim 1, wherein:

the second substrate is a multilayer substrate comprising an adjacent layer adjacent the first substrate, the adjacent layer comprising a remote surface remote from the first substrate;

5 the adjacent layer of the second substrate comprises conductors and the open vias are defined therein; and

the heater substrate is bonded to the remote surface of the adjacent layer.

8. The micro-relay device of claim 1, wherein:

10 the first substrate, the second substrate, and the heater substrate each comprise at least one of silicon, glass and ceramic.

9. The micro-relay device of claim 1, wherein:

the suspended heater element comprises at least one of polysilicon, platinum, nickel and chromium.

10. The micro-relay device of claim 1, wherein:

15 at least one of the substrates comprises a conductive plane adjacent the channel.

11. A micro-relay device, comprising:

a non-conductor gas;

a first substrate and a second substrate bonded together;

a channel defined in at least one of the substrates;

20 liquid mercury in the channel;

first, second, and third electrodes spaced along the channel and connectible by the liquid mercury;

25 first and second open vias defined in at least one of the substrates in fluid communication with the channel, the open vias containing the non-conductor gas; and

30 first and second heater substrates each comprising a respective suspended heater element, the first and second heater substrates in fluid communication with the first and second open vias, respectively, and operable to selectively cause the non-conductor gas to separate the liquid mercury between the first and second electrodes and the second and third electrodes, respectively.

12. The micro-relay device of claim 11, wherein:  
the first substrate comprises at least one layer and at least one structure selected from  
a conductor, the open vias, the first, second, and third electrodes, a subchannel,  
and a ground plane.

5 13. The micro-relay device of claim 11, additionally comprising:  
first and second subchannels defined in at least one of the substrates, the first and  
second subchannels respectively connecting the first and second heater  
substrates with the channel.

10 14. The micro-relay device of claim 11, wherein:  
the first substrate comprises a remote surface remote from the second substrate;  
the first and second heater substrates are bonded to the remote surface of the first  
substrate; and  
the micro-relay device additionally comprises bonding pads on the remote surface of  
the first substrate and conductors extending between the first and second  
15 suspended heater elements and the bonding pads.

15 15. The micro-relay device of claim 11, wherein:  
the first substrate comprises an adjacent surface adjacent the second substrate;  
the first and second heater substrates are bonded to the adjacent surface of the first  
substrate; and  
20 the micro-relay device additionally comprises bonding pads on the adjacent surface of  
the first substrate and conductors extending between the first and second  
suspended heater elements and the bonding pads.

25 16. The micro-relay device of claim 11, wherein:  
the first substrate comprises a remote surface remote from the second substrate;  
the second substrate is a multilayer substrate comprising an adjacent layer adjacent the  
first substrate;  
the adjacent layer comprises an adjacent surface adjacent the first substrate and a  
remote surface remote from the first substrate;  
30 the first and second heater substrates are bonded to the remote surface of the adjacent  
layer;

the channel and the open vias are defined in the adjacent layer and the first, second and third electrodes are on the adjacent surface of the adjacent layer; and the micro-relay device additionally comprises first and second subchannels defined in the first substrate, bonding pads located on the remote surface of the first substrate, and conductors extending through the first substrate between the first and second suspended heater elements and the bonding pads.

17. The micro-relay device of claim 11, wherein:

the first substrate comprises a remote surface remote from the second substrate; and the micro-relay device additionally comprises:

adjacent the channel, a ground plane impedance matched to a high frequency signal through the mercury, and a bonding pad on the remote surface the first substrate, and further conductors extending between the ground plane and the bonding pad.

18. The micro-relay device of claim 11, wherein:

the first substrate, the second substrate, and the heater substrate each comprise at least one of silicon, glass and ceramic; and the first substrate, the second substrate, and the heater substrate are of different materials.

19. The micro-relay device of claim 11, wherein:

the first and second suspended heater elements each comprise at least one of polysilicon, platinum, nickel and chromium; and the first and second heater substrates comprise silicon and define respective undercuts.

20. The micro-relay device of claim 11, wherein:

the second substrate comprises a conductive plane adjacent the first, second, and third electrodes and separated therefrom.